Forest-Poverty Dynamics: Current State of Knowledge

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Chapter 3

Forest-Poverty Dynamics: Current State of Knowledge

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Abstract
This chapter reports on evidence about the role of forests and trees in alleviating poverty and supporting wider human well-being. It considers how, whether, where, when and for whom forests and trees are important in forest-poverty dynamics. We organise the evidence according to four possible relationships between forest products and ecosystem services and poverty: 1) helping households move out of poverty; 2) supporting well-being through subsistence, food security and cultural and spiritual values; 3) mitigating risks; and 4) decreasing well-being by generating negative externalities that could significantly contribute to trapping or moving households into poverty. The evidence shows that these relationships are strongly context-dependent, varying with geography and social, economic and political contexts. However, across contexts, we most commonly observe that forest and tree products and services help the poor to secure and stabilise their livelihoods, rather than either helping them exit poverty or driving them into poverty.

3.1 Introduction

Forests and tree-based systems[5] are vital resources for sustaining human populations around the world (Sjaastad *et al.*, 2005; Ali, 2018; Cheng *et al.*, 2019). In tropical countries, forests contribute an average of 22% of household income in communities near forests (Angelsen *et al.*, 2014), which generally have high poverty rates (Sunderlin *et al.*, 2008). *Agroforestry* systems are also commonly used by poor farmers and have the potential to increase their incomes, especially with improved genetics and markets (Leakey *et al.*, 2005). Thus, both *sustainable forest management* and agroforestry are widely claimed to be important for achieving the first SDG (Griggs *et al.*, 2013; Lawlor *et al.*, 2019). In this chapter, we assess the available evidence for these claims. To set the stage, we first review some of the central narratives and myths about poverty and forests.

One of these central narratives is that rural populations who rely on *shifting cultivation* and pastoralism, including many *forest-proximate* populations, need to be 'settled' in fixed communities to develop. This is rooted in the idea that their traditional grazing and small-scale cultivation systems trap them in poverty and are responsible for *deforestation*, despite evidence to the contrary (Curtis *et al.*, 2018; Thu *et al.*, 2018; Dressler *et al.*, 2020). This framing of smallholders as responsible for deforestation has persisted since colonial rule and has been used to justify claims on forests for large-scale production of global commodities such as timber, at the expense of local forest stewards (Dove, 1983; Doolittle, 2007). This discourse remains common in debates over climate change (Weatherley-Singh and Gupta, 2015; Skutsch and Turnhout, 2020). The potential of shifting cultivation systems to generate joint benefits for *livelihoods* and climate change *mitigation*, e.g. in building below-ground carbon stocks, has been largely ignored (Ickowitz, 2006; van Vliet *et al.*, 2012; Bruun *et al.*, 2017; Dressler *et al.*, 2017; Bruun *et al.*, 2018).

In contrast, agroforestry has been widely accepted as a way to achieve the 2030 development agenda (Garrity, 2004; Waldron *et al.*, 2017; Agroforestry Network, 2018). Agroforestry systems are appealing because they provide a suite of products and services that contribute to *poverty alleviation* and improved *human well-being*. However, agroforestry is just one of a whole spectrum of trees on farms and in landscapes that can make these contributions.

Another theme in the literature has been the potential for harvest and sale of diverse *non-timber forest products* (NTFPs) to both conserve forests and alleviate poverty. As we summarise below, there is substantial evidence that poor households use NTFPs to maintain their socio-economic and cultural status, but less evidence that they can leverage them to move out of poverty. And while forest products have been shown to help smooth income and consumption, it is not clear whether and when they are the preferred insurance mechanism. In many settings, forests may be more important for *ecosystem services* that are inputs to quality of life and agricultural production, rather than as sources of forest products.

This chapter summarises current knowledge of the role of forests and trees in poverty dynamics, considering the full range of products and services that are sold, consumed, or used as production inputs. Other than the formal timber sector (Box 3.1), most contributions of forests are either excluded or not attributed to forests in the official economic statistics that are the basis for national poverty

5 Throughout this assessment report, all terms that are defined in the glossary are introduced for the first time in a chapter using italics.

rates (Box 3.2). Thus, we draw on the scientific literature for evidence on how, whether, where, when and for whom forests and trees play the four possible roles in poverty dynamics posited in Chapter 2: (1) helping people move out of poverty; (2) supporting well-being through subsistence, *food security* and cultural and spiritual values; (3) mitigating risks, and (4) decreasing well-being by generating negative externalities that could significantly contribute to trapping or moving households into poverty. For this fourth role, we focus on evidence regarding whether the forest itself has negative effects on local communities (Lyytimäki, 2015), distinct from the negative effects associated with the process of deforestation (reviewed briefly in Section 3.6) and with the imposition of strict forest protection rules that exclude local people (Byg *et al.*, 2017; Poudyal *et al.*, 2018), which are addressed in the context of protected areas in Chapter 5.

We find ample evidence that *forest ecosystem* goods and services affect poverty dynamics, with some evidence on how such dynamics vary with geography and socio-demographics. We focus on differences in how the dynamics play out for men and women. There is relatively more evidence on forest products as part of the second and third roles and relatively less evidence both on services and on the first and fourth roles. This is reflected in the varying lengths of the following sections on the four forest-poverty dynamics. In each section, we synthesise the existing literature, with emphasis on regions with the highest poverty rates (sub-Saharan Africa), the highest poverty headcounts (South Asia), and the most dramatic reductions in poverty in recent decades (China).

Firewood is a critical resource for rural households in many countries
Photo © Nelson Grima

Box **3.1**

Formal timber sector

Focusing on the region with the highest poverty rates, FAO estimates that 79 million m^3 of wood was harvested as industrial timber in Africa in 2018 (FAO, 2019), but this is widely recognised as a substantial underestimate due to large-scale illegal felling and trade of logs in many countries. The formal forest sector contributed less than 1% of the total GDP of sub-Saharan Africa in 2011, rising above 10% in only one country (Liberia) (FAO, 2014). These industrial wood harvests are destined both for growing regional markets and for export, largely to China. In 2009, 78% of Africa's timber exports were bound for the Chinese market, having risen from 35% in 2000 (IIED, 2014). In turn, estimates for the extent of illegal logging are high, but difficult to quantify and confirm by its very nature (Kleinschmit *et al.*, 2016).

During the decade from 1990 to 2000, about half a million people were directly employed in the formal, primary wood production and wood industry sector in Africa (Lebedys and Yanshu, 2014). This represented a small (<1%) and declining fraction of the labour force (FAO, 2005; Whiteman and Lebedys, 2006; FAO, 2014). However, the FAO also estimates that at least three times more people are employed in the informal sector, mainly related to fuelwood and charcoal, than in the formal forestry sector (FAO, 2014). In particular, the charcoal trade accounts for a large share of incomes within the informal forest products sector (Mwampamba *et al.*, 2013; FAO, 2014; Jones *et al.*, 2016; Chiteculo *et al.*, 2018) and may provide jobs for millions of people.

3.2 Movement Out of Poverty

Forests and trees in the landscape could help reduce the proportion of people living in poverty, by enabling households to increase their incomes through sales of forest and tree products (Belcher, 2005). It is difficult to evaluate whether, where and for whom this has occurred without longitudinal data. Angelsen *et al.* (2014) and Miller and Hajjar (2020) point to panel survey data as particularly valuable for understanding this role of forests, trees and agroforestry. Lacking long term panel data, researchers typically examine contributions to household income, expenditures or assets, rather than the role of forests in lifting people out of poverty over time (Miller *et al.*, 2017). Based on this largely cross-sectional and descriptive literature, the consensus view that emerged in the 2000s was that fundamental structural barriers generally prevent poor people from using forest and tree products to exit poverty (Wunder, 2001; Belcher *et al.*, 2005; Pérez, 2005). This is consistent with a recent literature review (Miller and Hajjar, 2020), which found only 12 studies that "described a social group (e.g., household, community or region) as moving out of poverty due at least in part to forests," i.e. through sales of timber or non-timber forest products. In the context of this pessimism about the potential for substantial numbers of people to use forests and trees to exit poverty, we seek to identify conditions that have allowed poor people to leverage tree and forest products to climb out of poverty. In these case studies, we give careful consideration to who has participated, i.e., who has benefitted. Ongoing policy changes discussed in Chapter 5 are also creating new conditions and offering new ways that the poor can leverage forests to raise their incomes above the *poverty line*, such as payments for ecosystem services (see Box 5.2 on the Conversion of Cropland to Forest Programme in China).

Harvesting bush mango (Irvingia gabonensis) for local consumption and trade, Ekuri, Nigeria
Photo © Terry Sunderland

Box **3.2**

Collecting national information on the socio-economic dimensions of forests and trees

National statistical offices in most countries conduct household surveys to inform national decision-making on poverty and livelihood issues, but these usually collect little to no information on the use and benefits of forests and trees (FAO *et al.*, 2016; Miller *et al.*, 2017). This absence of information means that the contribution of forests and trees outside forests to households' welfare, and their role in *poverty reduction* often remain hidden (Scoones *et al.*, 1992; Luckert and Campbell, 2012).

Recognition of the need for national information on the socio-economic dimensions of forest and tree resources has spurred the development of multiple new tools in recent years. Building from foundational work on measuring forest livelihoods (Cavendish, 2000; Wollenberg *et al.*, 2007; Angelsen *et al.*, 2012), a team of experts from FAO, CIFOR, IFRI (International Forestry Resources and Institutions) and PROFOR (Program on Forests) and the LSMS-ISA (Living Standards Measurement Study – Integrated Surveys on Agriculture) initiative at the World Bank has now published a set of forestry modules and guidebooks on their use (FAO *et al.*, 2016). The Forestry Modules were piloted in Indonesia, Nepal and Tanzania with national-scale implementation completed in Turkey. These modules are now complemented by a parallel effort to develop a set of modules to capture the socio-economic values of trees on farms, which was piloted in Mali (Miller *et al.*, 2019). They have also informed related tools, such as Forest-SWIFT (Survey of Well-being via Instant and Frequent Tracking) (World Bank, 2019a) and LivWell (FLARE, 2019), capable of more rapidly capturing focused data on forest reliance and poverty.

The main goal of these modules and the guidebooks describing their use is to provide a mechanism for national statistical offices to collect forest- and tree-related information in regular national-level household socio-economic surveys, thereby filling key information gaps on the contribution of forests and other environmental resources to income, welfare and livelihoods. The modules are adaptable to different scales from local communities through to a whole country. Therefore, they are also relevant to a range of other potential users, including researchers, donors, other government agencies (e.g. forestry departments) and non-governmental organisations (NGOs) interested in improved information on the socio-economic dimensions of forests and trees in broader landscapes.

In one of the earliest reviews that concluded forests have a limited role to play in lifting people out of income poverty, Wunder (2001) argued that timber is the product most likely to generate enough profits to reduce poverty, but that those profits are largely captured by capital intensive and politically powerful actors. In Box 3.5, we describe a unique case in which poor communities have profited from timber, partly because they hold secure collective *tenure* rights. This points to the decentralisation of forest ownership and management rights as one way to enhance the role of forests in poverty alleviation, consistent with systematic reviews that have found decentralisation effectively increased local incomes in the few cases where it has been rigorously evaluated (Samii *et al*., 2014). While acknowledging that "forest-based development success stories … are rare, especially among the developing countries," Palo *et al.* (1999) pointed to Finland where timber exports "played a vital role in economic development." In fact, the timber sector contributed to the economic development of many countries in northern Europe and North America that now have among the highest incomes in the world. These same countries continue to benefit from the trade in timber harvested in the Global South, thus contributing to the structural barriers that limit the ability of the poor in the Global South to leverage timber resources to exit poverty (Box 3.6).

Non-timber forest products are generally more accessible to poor households but offer only low returns to their labour (Wunder, 2001). López-Feldman and Wilen (2008) developed a theoretical model and examined a case study in Mexico showing that the poorest households, with the lowest opportunity costs of time and fewest alternative income-generating opportunities, are the most likely to be engaged in collection and sale of NTFPs. While this means that NTFP income flows disproportionately to the poor, it does not necessarily lift those households out of poverty, especially when forest resources are open access (and therefore susceptible to overexploitation and dissipation of rents) and when access to transportation, markets and other public services are limited (Belcher *et al.*, 2005). As Shackleton *et al.* (2008) concluded, "while key in enhancing the livelihood security of the poorest households, these products were unlikely to provide a route out of poverty for most, although there were exceptions." These exceptions can be created by more equitable forest policy (Larson and Ribot, 2007) or better market access (Scherr *et al.*, 2003). Market access is in turn shaped by consumer demand, globalisation, demographic trends, and expansion of communications or road infrastructure, which therefore can open windows of opportunity for poor people to harness forest products as a way to exit poverty, as illustrated by shea butter in Box 3.7.

As with forests, the rural poor face structural barriers to harnessing agroforestry to exit poverty. Russell and Franzel (2004) point to the need to expand market opportunities for smallholders, including for high-value products such as vanilla, as described in Box 3.8.

3.3 Role of Forests in Maintaining Human Well-being

This section reviews the evidence on how the poor secure their well-being by drawing on the multiple benefits of forests and trees, including both final and intermediate goods and services, both traded in markets and consumed. Standard measures of income and poverty as reflected in official statistics only credit forests for income from final goods and services traded legally in markets (Box 3.1). However, forests and trees also provide both tangible and intangible inputs to production and to household well-being (e.g. fodder, pollination, food and sacred places), which do not pass through markets and therefore are excluded from national income accounts.

3.3.1 Wood products

The harvest and processing of timber provide employment and income to millions of people worldwide. Exact numbers are difficult to obtain because this mostly occurs through the informal sector. FAO (2014) estimated that there were 54.2 million people employed in forestry, logging, and secondary manufacturing (sawn wood, panels, and paper) worldwide in 2010. In a report for the FAO Farm and Forest Facility, Verdone (2018) estimated that smallholders produced USD 2-4

Box **3.3**

Bushmeat as an example of non-timber forest products

Wild meat or bushmeat harvesting around the world remains an important source of protein and, more importantly, micronutrients, for many rural households and vulnerable populations such as indigenous groups and children (Swamy and Pinedo-Vasquez, 2014). Poor families living in rural areas, isolated from markets, rely heavily on wildlife - including bushmeat, insects and fish - for food, nutrition, as well as an income source (FAO, 2013; Oishi and Hagiwara, 2015; McIntyre *et al.*, 2016; Wilkie *et al.*, 2016; Lo *et al.*, 2019). Bushmeat harvesting is important in helping rural households to achieve healthy nutrition and food security (Golden *et al.*, 2014; Cawthorn and Hoffman, 2015; van Vliet *et al.*, 2015; Reuter *et al.*, 2016; Nielsen *et al.*, 2018). In the Abun region of West Papua, Indonesia, for example, hunting has proved to be an important factor in fighting food insecurity, as wild meat accounted for 49% of the diets of respondents (Pattiselanno and Lubis, 2014). While bushmeat is often consumed locally by hunters and their households (Wilkie *et al.*, 2005; Agustino *et al.*, 2011), the surplus is sold to both other community members and traders, with the latter often re-selling in cities (Nasi *et al.*, 2011; Nielsen *et al.*, 2017). In addition, the harvest of bushmeat may have ancillary benefits for agriculture, by reducing predation on crops, livestock and people working in remote fields (Wilkie *et al.*, 2011; Rentsch and Damon, 2013; Lindsey *et al.*, 2015). Harvesting of bushmeat has long been controversial due to concerns over its conservation impacts, when endangered species are targeted, and its long-term sustainability (Agustino *et al.*, 2011; Lindsey *et al.*, 2014).

billion in timber products per year (an order of magnitude less than just the single largest forest products company), but USD 76-309 billion/year worth of charcoal and firewood. Charcoal provides energy for over 80% of urban households in sub-Saharan Africa (Zulu and Richardson, 2013; Agyei *et al.*, 2020), and the informal charcoal industry provides employment to over half a million people in rural areas in Kenya alone (Njenga *et al.*, 2013).

In addition to generating employment and valuable forest products, harvesting timber and fuelwood for household use can reduce household expenditures and offer an additional income source. By growing trees on their own land, in woodlots or agroforestry systems, farmers can reduce the time and labour spent on gathering fuelwood (Njenga *et al.*, 2017), with the additional public benefit of reducing pressure on natural forests (Iiyama *et al.*, 2014). However, the ability of trees on farms to supply enough fuelwood for household consumption is dependent on the size of the landholding (Ndayambaje and Mohren, 2011), and thus many people remain reliant on wood collected off-farm. Even when trees on farms produce sufficient wood, it may be more lucratively sold as timber, poles or specialty products than used for fuelwood (e.g. in the case of *Acacia catechu* in India). Studies show that harvest and sale of timber (Antinori and Bray, 2005; Sikor and Baggio, 2014) and other wood-related forest products are important ways in which households augment their incomes (Humphries *et al.*, 2020; Macqueen et al., 2020).

3.3.2 Non-timber forest products

Compared to timber, non-timber forest products, including fuelwood (generally defined separately to NTFPs) and a wide range of other products, are less likely to enter the market economy and thus, less likely to be recorded in official economic accounts. This has meant that "the constant and profound reliance on forests by local people was under-observed by both Bureaux of Statistics and Forestry Departments in government" (Shepherd *et al.*, 2020), although there are efforts to remedy this (FAO *et al.*, 2016; Sorrenti, 2017). In contrast, the scientific literature of the past 25 years has provided a much richer understanding of the roles played by NTFPs in forest-poverty dynamics. In reviewing this literature, we include both plant and animal products from both forests and trees outside the forest. In many forest ecosystems across the world, including West and Central Africa, Brazil, Peru, India, and Indonesia, wild animals are important as both high-value market products and critical sources of protein (Box 3.3). In Section 3.2.4, we highlight the ways that households use NTFPs to increase their food security and improve their nutritional status, as perhaps the most important contribution of this category of forest benefits to supporting human well-being.

Numerous studies have found that poor, rural populations are disproportionately dependent on NTFPs to meet their basic needs (Shackleton and Shackleton, 2004; Belcher *et al.*, 2005; Heubach *et al.*, 2011; Vira and Kontoleon, 2012; Wunder *et al.*, 2014; Leßmeister *et al.*, 2018). In many cases, rural people who depend on forest products live in remote areas with limited access to basic infrastructure, such as motorable roads, making it difficult to access markets and other services (Belcher *et al.*, 2005).

NTFPs are generally managed as open access resources and can be harvested using low-cost and/or traditional technologies (Belcher *et al.*, 2005). For rural dwellers with little financial and physical capital, the affordability and low barrier to entry of NTFP collection make them a viable livelihood strategy. As discussed in Section 3.4, their specific role in household livelihoods is often as a safety net and buffer during times of need such as natural disasters, crop failure, or family illnesses and periods of financial struggle (Leßmeister *et al.*, 2018). Closely related to the role of safety net, NTFPs are also used for seasonal gap filling, i.e., they are collected and sold seasonally based on the availability of time and labour that fluctuates with crop harvesting and planting seasons (Arnold *et al.*, 2011; Leßmeister *et al.*, 2018).

NTFPs play multiple roles in rural livelihoods. They can be collected and used directly for food, medicine, home construction and other traditional purposes. Studies have demonstrated that people who live near areas with more forest and tree cover have more diverse and nutritious diets (Powell *et al.*, 2011; Ickowitz *et al.*, 2014; Powell *et al.*, 2015b; Baudron *et al.*, 2017; Hall *et al.*, 2019). The micronutrients provided by forest foods improve health outcomes and prevent stunting and impairments of cognitive development (Johnson *et al.*, 2013; Ruel and Alderman, 2013; Vinceti *et al.*, 2013). NTFPs also serve as inputs to production, e.g. fodder, mulch and poles for constructing fences. Both intermediate and final products may also be sold, helping generate cash to pay school fees, purchase food from markets, and acquire agriculture inputs (Arnold *et al.*, 2011; Kar and Jacobson, 2012; Hall *et al.*, 2019).

One particularly important role of forests is as a 'natural pharmacy' or source of medicinal plants that play important health care roles for people living in remote rural areas where modern medicine is not accessible. A significant proportion of the population in tropical Asia, Africa and Latin America (Colfer *et al.*, 2006) relies on medicinal plants that form an integral part of their primary health care systems because of affordability, access and effectiveness. As the oldest known health care products, they constitute the medicines used by up to 75-80 % (RAFI, 1994; Ten Kate and Laird, 2020) of the population in developing countries, about 3.5 billion people (WHO, 1993). Cunningham (1993) estimates that 70-80% of Africans consult traditional medical practitioners for health care. Colfer *et al.* (2006) have documented a large body of literature on the wide use of medicinal plants in traditional health care systems thus contributing to the well-being of rural *forest-dependent* people in most regions of the world. Also, the market for them is large and expanding, meaning that they can also generate cash income. Further, medicinal plants are important for pharmacological research and drug development when they are used as basic materials for the synthesis of drugs or as models for pharmacologically active compounds, thus offering the opportunity for increased income for custodians and knowledge holders of such plants through bioprospecting ventures. However, with increased deforestation and *forest degradation*, many such plants are threatened with extinction leading to a loss of health care benefits for those who depend on them.

The literature on the contribution of NTFPs to rural livelihoods is dominated by local level case studies (Angelsen *et al.*, 2014). Some studies have found high dependence on NTFPs (Pattanayak and Sills, 2001; McSweeney, 2004; Debela *et al.*, 2012), but results across studies even within the same region can differ drastically (Leßmeister *et al.*, 2018). This is partly because the diversity of NTFPs and the level of dependency vary greatly with the local context. Belcher and Kusters (2004) also attribute this inconsistency to the lack of an agreed-upon definition of NTFPs and variation in focus, scale, approach and methodology. For instance, studies vary in whether they include relatively low-value products collected in high volumes like fodder, mulch and fuelwood. Some studies focus on specific NTFPs and extrapolate claims on NTFP dependence based on those select products (Belcher and Kusters, 2004; Belcher *et al.*, 2005; Ahenkan and Boon, 2011; Leßmeister *et al.*, 2018).

To generate a more global understanding of NTFPs, the Center for International Forestry Research's (CIFOR) Poverty Environment Network

(PEN) applied consistent methods to estimate "environmental income" derived from forests and other non-cultivated lands across sites in 24 developing countries (Angelsen *et al.*, 2014). Across their study sites, environmental income accounts for an average of 28% of household income, 77% of which originated from forests (Angelsen *et al.*, 2014). Only 10.4% of households in the sample used environmental resources, predominantly forests, as their primary safety net (Wunder *et al.*, 2014), as discussed further in Section 3.4.

3.3.3. Products from trees on farms

More than 43% of agricultural land globally has at least 10% tree cover on-farm, and thus, trees on farms affect the livelihoods of hundreds of millions of farmers (Zomer *et al.*, 2016). Agroforestry practices directly contribute to increased income through sales of tree products, increased yields, or payments for sustainable land-use practices through payments for ecosystem services (PES) and certification programmes. Agroforestry and trees on farms can produce high-value tree crops, such as rubber, coffee, cacao, leaves, cashews, macadamia and shea nuts. Rubber agroforestry, for instance, is widely practised in South and Southeast Asia as a low-input production system that generates significant income and can enhance tenure security (Gouyon *et al.*, 1993). Rubber can be intercropped with food crops, fruit trees or timber species in diverse agroforestry systems, which can substantially increase net farm incomes as well as provide resiliency to rubber price fluctuations and promote environmental benefits (Viswanathan, 2008; Somboonsuke *et al.*, 2011; Jessy *et al.*, 2017; Kenney-Lazar *et al.*, 2018). Smallholder farmers may earn two to six times more from rubber monoculture systems with a high-value intercrop, such as pineapples, corn, custard apple, salacca or rice (Somboonsuke *et al.*, 2011). Barriers limiting the adoption of agroforestry systems including their technical complexity and increased labour and input requirements. The economic viability of these systems is also debated (Kenney-Lazar *et al.*, 2018).

Agroforestry can increase income and food security by providing various foods for household consumption and sale, particularly from the use of multi-strata agroforestry systems surrounding houses, known as home gardens (Soemarwoto, 1987). In Vietnam, for example, home gardens were found to contribute between 13-54% of total household income (Trinh *et al.*, 2003), and in Indonesia, to 7-56% of total income (Soemarwoto, 1987). In Brazil, small home gardens had the highest net income per hectare and highest income-to-cost ratio, followed by medium-sized home gardens, as compared to commercial agroforestry enterprises, commercial agroforestry by smallholder farmers, enriched fallow, pasture with babassu and *swidden* cultivation (Cardozo *et al.*, 2015). Brazilian small home gardens generated the equivalent of 7.47 minimum wages per hectare, and medium-sized home gardens generated 6.77 minimum wages per hectare, indicating high productivity of these systems, while also maintaining high levels of *biodiversity* (Cardozo *et al.*, 2015). For comparison, pastures with babassu only generated 0.77 minimum wages per hectare and shifting cultivation systems generated 1.85 minimum wages per hectare during the cultivation phase (not including fallow phase) (Cardozo *et al.*, 2015). In sub-Saharan Africa, fruit trees provide a significant source of income for many families, in some cases acting as a safety net and provide supplemental income to cover everyday household expenditures and education costs (Schreckenberg *et al.*, 2006). Recent evidence from Uganda using data from a national survey of nearly 1,400 households over a 10-year period shows that households that increased the area they allocated to trees on farms – particularly fruit trees – saw a significant increase in their total consumption (Miller *et al.*, 2020).

Many tree-crop-based systems are transitioning towards more intensive plantation systems, e.g. shifting along a gradient from high shade to unshaded coffee production systems. This change towards intensification can increase yields and incomes but at the cost of biodiversity and system *resilience* (Steffan-Dewenter *et al.*, 2007). Agroforestry systems managed for a greater diversity of products, as opposed to only one commodity crop like coffee, can increase resilience to market shocks and fluctuations. Crop diversity has also been shown to significantly reduce the probability of household poverty in some contexts (Michler and Josephson, 2017). There are trade-offs between productivity and environmental sustainability, but optimal configurations across both objectives may be found, such as with low-shade agroforestry systems (<30% shade) that maintain productivity while creating benefits for climate *adaptation*, climate mitigation and biodiversity (Blaser *et al.*, 2018). Coffee agroforestry can diversify and decrease expenditures or increase household incomes, through the consumption or sale of fuelwood, fruit and lumber beyond the sale of coffee (Rice, 2008). Under sustainable management, these types of agroforestry practices yield high-value products along with the commodity crops, while maintaining tree cover that delivers ecosystem services. Exploiting these resources from agroforestry can help relieve pressures on *primary forests* to supply these products (Rice, 2008).

3.3.4 Forests and trees for food security and nutrition

Forests and tree-based systems contribute to food security and *nutrition*, particularly for vulnerable groups such as children and pregnant and nursing women. In this section, we focus on the direct provisioning of wild and cultivated foods such as edible plants, fruit, nuts and seeds from forests and trees, as one of a suite of ways that these resources support food security and nutrition (Vira *et al.*, 2015; HLPE, 2017; Rasmussen *et al.*, 2017; in addition, see Box 3.3 on wild meat harvesting). The indirect contributions of forests and tree-based systems are discussed in the next section.

Food harvested from the wild contributes to food security because of its nutritional value (Boedecker *et al.*, 2014). While wild foods may not necessarily contribute to the caloric intake of rural households, studies have indicated that their role is particularly important in providing essential vitamins and minerals (Powell *et al.*, 2015a; Vira *et al.*, 2015; Asprilla-Perea and Díaz-Puente, 2019). The collection of such wild foods is also a means of mitigating the risks and shocks that poor people face due to, for example, droughts, illness, conflict, a poor harvest (Pouliot and Treue, 2013; Clements *et al.*, 2014) or forced displacement for the creation or enforcement of strictly protected areas (Sunderland and Vasquez, 2020).

Evidence shows that in many countries rural populations living in or around forested areas rely, to diverse extents, on the harvesting of wild foods for their dietary needs (Sunderland, 2011; Sunderland *et al.*, 2013; Boedecker *et al.*, 2014; Rowland *et al.*, 2017). Hickey *et al.* (2016) carried out a comparative analysis at a global scale, which concluded that 77% of rural households surveyed

Box **3.4**

Sacred groves in Africa

Around the world, sacred groves represent a traditional form of community-based conservation, known to preserve areas that hold strong cultural and religious importance to local people (Oviedo and Jeanrenaud, 2007; Ormsby and Bhagwat, 2010; Bulkan, 2017). These sites can be individual trees, forest remnants, rivers, waterfalls, meadows, wildlife, sacred caves, lakes, hills and other sites (Bhagwat and Rutte, 2006; Ormsby, 2012; Liljeblad and Verschuuren, 2018) managed and sustained by a system of enduring religious beliefs and socio-cultural practices (Mgumia and Oba, 2003; Aniah and Yelfaanibe, 2016). The practice of establishing sacred groves is widespread across many countries in Africa, including Tanzania (Mgumia and Oba, 2003; Sheridan, 2009), Cameroon (Fru, 2014; Kemeuze *et al.*, 2016), Nigeria (Onyekwelu and Olusola, 2014; Oyelowo *et al.*, 2014; Daniel *et al.*, 2016), Ghana (Ormsby, 2012; Aniah and Yelfaanibe, 2016) and Ethiopia (Aerts *et al.*, 2016; Orlowska and Klepeis, 2018). Sacred groves exist throughout tropical Africa, and are usually designated as places for rituals of initiation and sacrifice. Generally, they consist of patches of forest in agrarian landscapes and are commonly found in the long arc of forest-savannah transition zone (Sheridan, 2009). The ecological status of African sacred groves is associated not only with their spiritual significance but also with political, economic and legal processes (Sheridan, 2009).

Ghana is considered as having the highest number and concentration of sacred natural sites in Africa (Ormsby, 2012). It was estimated that over 1,900 sacred groves of varying sizes ranging from very small patches (less than 1 ha) to larger expanses of several thousand hectares are spread across the country (Ntiamoa-Baidu, 1995). In the central and northern Ethiopian highlands, 'church forests' are a strong and longstanding tradition where small fragments of forests, mostly the remaining native forests, are managed by the Ethiopian Orthodox Tewahido Churches and monasteries as sacred groves (Aerts *et al.*, 2016; Woods *et al.*, 2016; Orlowska and Klepeis, 2018). In Nigeria, sacred groves are a symbol of identity for most of the Yoruba People in the south-west region of the country, and were historically established outside their settlements (National Commission for Museums and Monuments, 2005).

Harvesting acai (Euterpe oleracea) in the state of Amapá, Brazil
Photo © Reem Hajjar

collected food from the wild, highlighting the extent to which such harvesting is an integral part of many livelihood strategies, particularly in developing countries. Both in Malawi (Johnson *et al.*, 2013; Hall *et al.*, 2019) and Indonesia (Ickowitz *et al.*, 2016) a positive correlation has been found between tree cover and dietary diversity. A number of multi-country meta-analyses have also served to confirm this positive relationship between forests and diets. Ickowitz *et al.* (2014), for example, in their meta-analysis of 21 African countries, found a statistically significant correlation between tree cover and dietary diversity among the diets of children in all 21 countries. Similarly, Rasolofoson *et al.* (2018) also identified a positive relationship in their analysis of 27 African countries. In contrast, Galway *et al.* (2018) found that deforestation and the loss of forest around villages and agricultural fields resulted in poorer dietary outcomes for children in sub-Saharan Africa.

Farmed produce are often unable to fulfil all the dietary requirements of a rural family, and wild food collection often serves to complement their nutritional needs (Fischer *et al.*, 2017; Nakamura and Hanazaki, 2017). In fact, reliance on agricultural production may lead to lower quality diets lacking in vitamins and micronutrients such as iron, zinc and vitamin B12 (Sunderland *et al.*, 2013; Cawthorn and Hoffman, 2015; Powell *et al.*, 2015a). This lack of quality in the diet has been termed the 'hidden hunger' (Ickowitz *et al.*, 2014; Fa *et al.*, 2015; Powell *et al.*, 2015a) and leads to malnutrition, which can have severe impacts on the development of young children, leading for example to childhood stunting with life-long consequences (Golden *et al.,* 2011; Temsah *et al.,* 2018). A study by Blaney *et al.* (2009) exploring the contribution of natural resources to the nutrition of the local population in a protected area in Gabon, found that the consumption by children aged 5 to 9 of products stemming directly from their environment, was the best predictor for nutritional status. Similarly, although overall natural foods were found to contribute only 12% of the energy requirements of villagers in the Gamba Complex of Gabon, they contributed an estimated 82% of protein, 36% of vitamin A and 20% of iron requirements (Blaney *et al.*, 2009). In this context, the role of wild foods collected from the forest is all the more important to help to combat micronutrient deficiencies.

Fruit trees, both wild and cultivated, are an important source of dietary diversity for many rural households. They have the advantage that they are often easy for households to domesticate and manage on their land (Willett *et al.*, 2019). Fruits like baobab, mango, papaya and orange are particularly vitamin-rich sources of nutrients (Vira *et al.*, 2015). A nationally-representative panel data study from nearly 1,400 households in Uganda, for example, showed that those that increased the share of trees on their farms, especially fruit trees, saw improved child health and nutrition outcomes (e.g. less child wasting and stunting) (Miller *et. al.*, 2020).

Box **3.5**

An example of how poor communities have profited from timber harvesting

In Mexico, as a result of a national agrarian reform that occurred in several waves in the 1900s (Bray *et al.*, 2006), many communities have control over and log forests with commercial timber potential. In the Yucatan region, forestry authorities, civil society organisations and the state government of Quintana Roo cooperated under the Forestry Pilot Plan, or *Plan Piloto Forestal* (PPF), to provide technical assistance to communities for commercial forest management. Bray *et al.* (2007) found a suggestive correlation of lower poverty rates with direct control over more of the value chain, i.e., via the establishment of sawmills rather than simply selling stumpage or logs. The distribution of benefits from logging also varies across communities, with some choosing to share profits within workgroups that manage particular stands and others investing in local social services or public goods, such as schools, drinking water systems and health posts, that benefit all families living in the community (Huelsz and Negreros-Castillo, 2014). This is particularly relevant for women, who typically do not participate directly in commercial forestry but do benefit from local social services.

3.3.5 Forest and tree inputs to production in other sectors

In addition to the sale and consumption of goods from forests and trees, many households derive benefits from the contributions of forests and trees to production in other sectors, most notably agriculture and fisheries. These indirect benefits are particularly important to poor households who cannot afford to purchase substitutes for the free inputs provided by forests and trees (Chavarría *et al.*, 2018). For example, hundreds of thousands of smallholders, half of them women, plant fodder trees in East Africa, where they reduce the cost of producing milk (Franzel *et al.*, 2014). The inputs include services generated as externalities of forests, such as reduced sedimentation downstream, and as a result of deliberate management of trees, such as shade and nitrogen fixation. They also include inputs gathered from forests, such as fodder and poles, and produced in tree-based agricultural systems. These systems are diverse, ranging from trees retained on farms following forest clearance, to simple agroforestry systems such as improved rotational fallow, alley cropping, intercropping and hedgerow systems, to complex agroforestry systems that mimic natural forest ecosystems (McNeely and Schroth, 2006). While there have been numerous initiatives to promote these tree-based systems because of their benefits to farmers and society in general, farmers must balance these expected benefits against potential costs of competition for resources and negative effects on the microclimate, such as increasing relative humidity and lowering air temperature in sub-humid zones (Kuyah *et al.*, 2016).

Forests and trees can increase crop and livestock productivity (Baudron *et al.*, 2019). Tree-based systems can increase agricultural yield and nutritional quality through various provisioning and regulating ecosystem services (Reed *et al.*, 2017; Barrios *et al.*, 2018). The resulting product diversification and regulating services that maintain productivity can increase resiliency to climate change and other shocks (Thorlakson and Neufeldt, 2012; Kenney-Lazar *et al.*, 2018; Quandt *et al.*, 2019). A review of 438 studies spanning over 20 countries across sub-Saharan Africa shows that crop yields increased under tree-based systems such as fallowing, tree-crop intercrop and alley cropping compared to treeless systems in 68% of the studies due to improved microclimate, nutrient cycling and soil fertility (Kuyah *et al.*, 2016). However, 18% of these studies also reported a decline in crop yields mainly due to trees competing with crops for nutrients, water and light (Kuyah *et al.*, 2016).

Likewise, at a landscape level, crop yields can be maintained or enhanced at a level comparable to intensive monoculture when forests and trees are incorporated effectively in an agricultural landscape (Reed *et al.*, 2017; Baudron *et al.*, 2019). The presence of trees and forests in agricultural landscapes showed an overall positive or neutral effect on crop yields in 52% of the case studies in a pan-tropical review of 74 studies (Reed *et al.*, 2017). In two studies in Ethiopia, livestock productivity

Box **3.6**

The forestry sector in the Congo Basin as an inequality machine? A brief overview of the issues

In many tropical forest-rich countries, among them, Cameroon and the Democratic Republic of the Congo (DRC), the exploitation of forests and forestland is justified by the promise of development and increased societal welfare.

When investigating the specific cases of Cameroon and DRC, we find that this development discourse is contradicted by the long stagnating national incomes (Alvaredo *et al.*, 2018) in both countries, and documented violation of rights and exclusion of indigenous people from access to forest resources and related benefits (Logo, 2010; Assembe-Mvondo *et al.*, 2013). Paradoxically, since the colonial period, the marginalisation of indigenous people and forest communities' rights at domestic level co-exists with an increasing proliferation of policies driven by international forest-related agreements that promote an improvement of their participation, land tenure security and benefit-sharing (Maggio, 1997; Adams and Hulme, 2001; Larson *et al.*, 2010; Schroeder, 2010; Sikor *et al.*, 2010). Over the longer term, the forest sector appears to have contributed more to the economic prosperity of European countries that have historically dominated forest exploitation and forestland conversion in the Congo Basin as colonial powers, namely Belgium, France and Germany (Hardin and Bahuchet, 2011; Coquery-Vidrovitch, 2017). More recently, China emerged as a new power in the region, engaging with a similar dual agenda of linking promises of development for societal welfare in exchange for the (over) exploitation of forests that are combined with forestlands and large-scale land acquisitions (Sautman and Yan, 2008; Germain *et al.*, 2018). Not least, state bureaucracies and national elites are also entangled in rent-seeking behaviour (Ross, 2015), with powerful groups having gained access and using their influence and power to capture and/or enlarge the forest rent. This is reflected throughout a set of dominant strategies in the politics of land acquisitions, forest concessions, trade and investment patterns (Ribot, 1999; Ekoko, 2000; Karsenty and Ongolo, 2012).

Social inequality within and among societies in different parts of the world is currently part of many public debates (Alvaredo *et al.*, 2018; UNDP, 2019) and often narrowly expressed in (economic) opportunities and outcomes, for example in access to education or participation in decision-making over the use of natural forests (Sen, 1997; Obeng-Odoom, 2020). Underlying those inequalities as starting points (opportunities) and finishing lines (outcomes) are multidimensional, socio-political processes that often feed into a machinery of increased 'production' of social inequalities (Afonso *et al.*, 2015). Inequality resulting from uneven distribution of, and access to, the many materials and immaterial benefits from forests in the tropics has been discussed to some extent in recent literature, for example with regard to global North-South dynamics driving and justifying access to forests and large scale conversion of forestlands in the name of development (Ribot and Peluso, 2003). Here, social inequality is manifested in institutional path-dependencies and power relations, defining who has the right to access and benefit. Other scholars refer to benefits and burdens in the context of climate change and specific policies and programmes (Ribot, 1999; Phelps *et al.*, 2010; Luttrell *et al.*, 2013; Pham *et al.*, 2014). Detailed accounts of the role of colonial exploitation in generating inequality, such as Peluso (1991) for the case of Java, are limited for the forest sector, in the Congo Basin and elsewhere. Much of the literature focuses on particular inequalities in benefit sharing within a particular tropical forest country, while often missing the link between major financial actors in the Global North investing in industries driving deforestation in the Global South (Galaz *et al.*, 2018). Scholars also highlight the underlying long-term dynamics of power and politics in the global forest and land-use sector, and the political economy establishing incentive structures and discursive practices which drive and justify unequal outcomes from tropical deforestation (Angelsen and Kaimowitz, 1999; Rudel, 2007; Dauvergne and Neville, 2010; Burgess *et al.*, 2012). Meanwhile, today's decision-making over forests and forestlands in the tropics seems still to be shaped by persistent myths that create barriers to transformation towards global forest sustainability (Delabre *et al.*, 2020). With emerging datasets on forest change, global trade, investments and related inequalities among countries, as well as increasing access to digital information in colonial archives, it is now crucial more than ever to examine the as yet largely unanswered question (McDermott, 2017) of 'who, and whose societies, benefit from tropical forest exploitation and deforestation?' And to what extent do current global forest governance arrangements reinforce or break with existing patterns of inequality?

and nutrient balances, and the nutritional value of crops both improved with proximity to a forest (Chavarría *et al.*, 2018; Wood et al., 2018).

The key ecosystem services from forests and trees that support crop production include nutrient cycling (Power, 2010), pollination (Garibaldi *et al.*, 2011), seed dispersal (Thrupp, 2000), soil formation (Hurni *et al.*, 2015), reduced erosion and leaching (Mbow *et al.*, 2014), natural pest and disease control (Karp *et al.*, 2013) and climate and water regulation (Daily and Matson, 2008). In particular, 'fertiliser trees' (that are grown in agricultural fields or pastures to increase nitrogen availability) can offer an alternative or supplement to fertiliser application, which can reduce expenditure on fertiliser and increase income through higher yields. Nitrogen-fixing trees maintain and enhance soil fertility by cycling atmospheric nitrogen, thereby increasing yields (Akinnifesi *et al.*, 2010; Ajayi *et al.*, 2011). A review of 90 studies suggests that maize yields increased, and crop production stabilised during drought after the integration of nitrogen-fixing trees on farms in Eastern and Southern Africa (Sileshi *et al.*, 2007). Similarly, incorporating trees in wheat fields increased nitrogen availability in soil, water use efficiency, reduced heat stress and increased yield significantly compared to wheat fields without trees (Sida *et al.*, 2018), resulting in higher net income (Place *et al.*, 2005; Kuntashula and Mungatana, 2013; Coulibaly *et al.*, 2017; Amadu *et al.*, 2020).

Forests and trees support pollinators and natural predators of crop pests. Although many major crops are self- or wind-pollinated, wild pollinators such as bees, butterflies, birds and bats directly affect the productivity of 75% of globally important crops (Potts *et al.*, 2016). For instance, yields in coffee crops in Costa Rica and watermelons in California increased in sites near forest fragments due to more frequent visits by pollinators (Scherr and McNeely, 2008). Similarly, a global study found that pollinator richness increased crop yield across 89 crop systems (Dainese *et al.*, 2019). The stability of pollination services declines in crop fields with increasing distance from forests and trees (Garibaldi *et al.*, 2011).

Another key service is pest control. Incorporating forests and trees within agricultural landscapes creates heterogeneity in the habitat and supports diverse natural predators of crop pests (Maas *et al.*, 2016; Chaplin-Kramer *et al.*, 2019; Kebede *et al.*, 2019), especially in perennial crops (Pumariño *et al.*, 2015). For instance, forest cover in farmland improved pest control by increasing natural predators such as bats and birds in Costa Rica and Western Kenya (Karp *et al.*, 2013; Guenat *et al.*, 2019). Similarly, effective management of ants and shade trees increased crop yields in cocoa agroforestry in Indonesia (Gras *et al.*, 2016). Conversely, forest cover loss reduced agricultural production by 45% due to the loss of biological pest control in Indonesia (Yamamoto *et al.*, 2019).

Forests and trees can also increase crop productivity and resilience by improving microclimate conditions in agricultural landscapes (Pramova *et al.*, 2012). For instance, trees can buffer extreme climatic fluctuations such as temperature spikes that have negative impacts on crop growth (Hatfield, 2016). Shade trees have been found to enhance production by regulating temperature and humidity fluctuations in coffee agroforestry systems in Latin America (Lin *et al.*, 2008) and India (Nesper *et al.*, 2017). Trees in agricultural landscapes can also enhance understory growth by reducing air and soil temperature and by regulating water retention and gas exchange (Lott *et al.*, 2009).

In livestock systems, trees provide both the key service of shade and the key input of fodder. These systems include grazing livestock on pastures with trees and allowing livestock to graze on the trees or shrubs, as well as supplying tree cuttings as fodder for livestock. Fodder trees, when used as a protein supplement, improve milk and meat production, livestock growth, and livestock health and reproduction (Franzel *et al.*, 2014). This increase in productivity leads to improved incomes and food security. In East Africa, for example, fodder trees and shrubs contributed about USD 3.8 million annually to farmers' incomes by 2006 (Franzel *et al.*, 2008). At the household level, this translated to an increase in net returns of between USD 13- 334 per year in Zimbabwe, USD 30-114 per year in Kenya

Box **3.7**

Shea butter market as an example of NTFPs as a way out of poverty

The nuts of the shea tree (*Vitellaria paradoxa*), found in the dry savannah and grassy woodlands of Africa, are both consumed at home and sold in the market for end uses including food, oils and cosmetics. Shea nut prices increased five-fold from the 1990s to 2013 (Rousseau *et al.*, 2015). This strong market means that a single shea nut tree has an estimated net present value of USD 211 (IUCN Uganda, 2016). In particular, shea collection, processing and subsequent sale of shea-based products generate income and offer employment to rural women and children (Aboyella, 2002; Abdul-Mumeen *et al.*, 2013; Mohammed *et al.*, 2013; Sarkodie *et al.*, 2016). Laube (2015) finds it "unlikely that shea nut pickers will be able to substantially increase their production with labour shortages and dwindling access to shea trees". However, women involved in the shea business are more likely to effectively increase their family income when they have access to microcredit, e.g. through the Community Life Improvement Programme (CLIP) in northern Ghana (Robinson, 2001; Bawa *et al.*, 2017). At the country level, FAO estimated that Ghana exported 42,424 metric tonnes (MT) of shea worth USD 14.8 million in 2008 (FAOSTAT, 2008). This same quantity of shea nuts could have yielded 21,212 MT of shea butter at a total value of USD 21.2 million (Omane, 2014). The implication is that value addition through the processing of shea nuts into butter presents an opportunity for increasing income, improving livelihood outcomes and alleviating poverty.

and Uganda, and USD 68-503 per year in the Philippines due to increased production and income from cattle (Franzel *et al.*, 2014).

While not as well recognised as contributions to crop and livestock productivity, forests and trees also support fisheries. Fish and other products (e.g. freshwater prawn, crayfish and crabs) have long been recognised as an important source of protein for the poor, who consume less but are more dependent on (and have fewer substitutes for) these products in their diets, as compared to wealthier populations (Kent, 1997; Jones *et al.*, 2006; HLPE, 2014). A growing body of literature highlights the contribution that 'blue forests', notably mangroves, make in supporting local community well-being, livelihoods and food security (Himes-Cornell *et al.*, 2018). McIntyre *et al.* (2016) report that hundreds of millions of people globally benefit from low-cost protein and commerce that freshwater fisheries provide, particularly where alternative sources of protein and employment are scarce.

Deforestation, overexploitation or contamination of water by agriculture, mining or other land use changes can have drastic effects on aquatic foods with subsequent impacts on downstream people reliant on these systems for income, nutrition and food security (Carignan and Steedman, 2011). Forests play a role in the maintenance and regulation of aquatic food webs by regulating flow, controlling sedimentation rates, regulating in-stream temperature and contributing energy flows through terrestrial resource subsidies in the form of terrestrial fauna entering the aquatic food web. Losing this regulating function of forests impacts on the health of the people whose food security and nutritional needs rely on them. For example, in the Amazon Basin, fish is in many cases the most important source of protein consumed by traditional rural peoples. In freshwater streams and rivers, fish are dependent on fruits and seeds from riparian vegetation for their survival (Goulding, 1981).

Mangroves play an important role in the productivity of marine fisheries, providing habitat, spawning grounds and nutrients for a variety of fish and shellfish, including many commercial species. Falling leaves and woody matter from mangroves are essential to the marine food chain that supports fisheries (FAO, 2007; Hutchison *et al.*, 2014). Juvenile fishery species can hide among the roots of mangrove trees and grow to a size where they are less prone to predation, leading to higher survival rates. Fish and shellfish from mangroves support a large number of fishing and rural communities around the world providing them with income and food security. Mangroves contribute to the employment of an estimated 38.4 million people globally, of whom 90% are artisanal fishers (Hutchison *et al.*, 2014). As mangrove forests

Box **3.8**

Vanilla production as an example of agroforestry as a way out of poverty

Approximately 80% of the world's vanilla is produced in Madagascar, largely in the north-eastern SAVA region, constituting up to 26% of Madagascar's crop export revenue and up to 6.8% of the country's national revenue (Organisation Internationale du Travail, 2016; World Bank, 2019b). Vanilla orchids (*Vanilla planifolia*) are grown on other vegetation for support, including in native forest that has not been significantly altered (Hending *et al.*, 2019). In the SAVA region, these agroforestry plantations have become the main source of income for many farmers. Hänke *et al.* (2018) report that the cultivation of vanilla has improved the socio-economic status of smallholders, as indicated by income, education, access to electricity and ownership of assets. These benefits generally arise from contracts with vanilla exporters or collectors and thus are concentrated among smallholders able to obtain those contracts. Female-headed households are much less likely to get contracts because of their significant social disadvantages (e.g. lower labour availability and smaller fields). Additionally, tight integration with the export market results in both unstable prices (Zhu, 2018) and perceived exploitation due to the wide spread between the prices offered to smallholders and the export value.

are destroyed, local fish catches drop, leading to a direct loss in livelihoods. More broadly, the loss of mangroves may have significant negative impacts on the fisheries sector. Mangroves also contribute to aquaculture, both open-water estuarine mariculture (e.g. oysters and mussels) and pond culture (mainly for shrimps) (FAO, 2007). Shrimp farming, for example, has a high economic rate of return and has been promoted in several countries to boost the national economy and alleviate poverty.

3.3.6 Non-material contributions

The first SDG recognises that poverty is multi-dimensional, calling for a reduction "at least by half [in] the proportion of men, women, and children of all ages living in poverty in all its dimensions according to national definitions." Culture, religion and spiritual values are clearly important to human well-being and thus their loss is a form of impoverishment.

Forests and trees are significant to spiritual and cultural traditions central to the identity of forest-proximate communities, especially indigenous peoples (Oteng-Yeboah *et al.*, 2011; Asselin, 2015; Daniel *et al.*, 2016). Information on the cultural significance of forest resources can be gleaned from anthropological, ethnobotanical and ethnoecological studies (Toledo, 2002; Alexiades, 2003; Cocks, 2006). These cultural values manifest in ways ranging from forests being objects of animist-based beliefs to traditional forest products marketed globally based on their joint natural and cultural attributes. Box 3.4 provides an example of the spiritual role of forests. Specifically, for people who traditionally lived near and with forests, one dimension of poverty alleviation is restoring the cultural, spiritual and religious values of forests.

Cultural identity and integrity

Forests are culturally important to the self-identification of indigenous peoples in the role they play in their well-being, and are an important factor in non-material aspects of quality of life of many indigenous peoples (IPBES, 2019). They symbolise cultural cohesion in a rapidly changing environment and, hence, cultural integrity. Intimately linked with ancestry and cultural heritage, forest symbols strengthen social and cultural identity. For example, most sacred forests in southeastern Nigeria and coastal Kenya are important sites for the coronation of paramount rulers, exclusive meetings for spiritual leaders, traditional rites and celebrations (Kibet and Nyamweru, 2008; Umazi *et al.*, 2013; Daniel *et al.*, 2016).

This value is not limited to forests or indigenous populations. For example, studies of immigrants from lower-income countries living in Europe highlight the spiritual and cultural importance of agroforestry as a connection to their culture and traditions (Mazumdar and Mazumdar, 2012). In the western Brazilian Amazon, social movements and a state government have emphasised cultural connections to the forest among descendants of migrants who came to the region to tap rubber from the native *Hevea brasiliensis* trees (in the late 1800s and during WWII). Rubber tappers lived in the forest and walked forest trails daily to tap trees for rubber. Their livelihoods thus required conservation of the forest, and this brought them into conflict with farmer and cattle ranchers who migrated to the region in the 1970s and 1980s. Thus, as recounted by Gomes *et al.* (2012), "the term 'rubber tapper' acquired a new emphasis that highlighted sustainable resource use and traditional claims to forested lands, set against an unsustainable development model involving land speculation and deforestation." In 1998, the state of Acre elected a new government that emphasised 'florestania' or forest citizenship, thus recognising the centrality of forests to the culture and identity of rubber tappers and claiming those cultural traditions and that identity as a source of pride for the entire state. To support both the ecosystem services and the cultural values associated with rubber tapping, the government offered a subsidy for rubber as a mechanism to simultaneously increase rubber-tapper incomes, incentivise protection of the forests with rubber trees and recognise the cultural value of rubber-tapping (Sills and Saha, 2010; Jaramillo-Giraldo *et al.*, 2017). As Gomes *et al.* (2012) argue, "the cultural content of rubber tapper identity is rooted in historical material conditions" and thus, its continuation depends on the competitiveness of the forest economy (Hoelle, 2015).

Importance of forests as sacred spaces

Traditionally managed by indigenous communities, in many regions forests are considered sacred and are governed by a set of traditional norms and rules (Munyi and Mutta, 2007; Rutte, 2011; Ngoufo *et al.*, 2014). Preserved forest patches are usually close to human settlement, thus, forming an integral part of traditional closely-knit rural communities (Ray *et al.*, 2014). They provide the venue for social, cultural and religious ceremonies and a range of products for traditional ceremonies from food and beverages to costumes and musical instruments.

Most sacred forests in south-eastern Nigeria are used for the coronation of paramount rulers and are deemed sacred to non-initiates, as an exclusive meeting place for the members of the Ekpe occult society (Umazi *et al.*, 2013; Daniel *et al.*, 2016). In Kenya, the Kayas (sacred forests) of the Mijikenda tribal group fulfil many roles: they are burial sites of an ancestral or founding figure, or of revered community elders, are former battlegrounds or the sites at which a community leader first established title to the location. They are also sites of seclusion for initiates, meeting places for secret societies and areas where community rituals and celebrations are held (Kibet and Nyamweru, 2008).

Many religions that originated in Central and South Asia, China and Japan (including Buddhism, Daoism and Hinduism) integrate nature as a critical component of their belief systems (Dudley *et al.*, 2009). Sacred forests provide essential spiritual services to Tibetan Buddhists, who believe in both the Buddha and local deities. For them, sacred forests are naturally forested Holy Hills where village gods that protect a person for their entire life (Liu, 2006) and spirits are believed to reside (Taylor and Kaplan, 2005). Improper actions or disrespect of these forests are punished by misfortunes. Rituals are practised each year to consecrate the sacred forests and honour the gods and spirits that live there. The traditional annual rituals provide an essential mechanism to integrate widely scattered households into a close-knit community (Liu, 2006). Sacred forests also provide similar spiritual services to the Dai people who live in Southwest Yunnan Province of China, Northwest Vietnam, Northern Thailand and upper Laos (Taylor and Kaplan, 2005). To the extent that cultural practices contribute to a shared sense of belief among communities, they are essential complements to economic approaches to livelihoods through the collective community *capabilities*.

Importance of forests in customary and religious rituals

In a study of the uses of fallow tree species in Ho (Ghana), Asamoah (1985) found that half of the identified species were valued in customary rites. Most musical instruments are made from forest products. For example, the seed shells of *Chrysophyllum albidum* and *Mammea africana* are worn by dancers as rattles and the wooden strips of *Ricinodendron heudelottii* are used to make xylophones in Igboland, Nigeria (Okigbo, 1980). The long history of the sites and the related rituals, and the reference to the ancestors give these forests their high value (Darr *et al.*, 2009).

In Nepal and India, all Hindu families have to perform pujas (religious rituals) on certain occasions that require plants and their products. Traditional Hindu books such as *Ramayana, Mahabharata* and *Veds*, all call for preservation of the forest as a part of the cultural heritage. In Hindu theology, some plant species (such as *Ficus religiosa*) are considered as "incarnations or symbols of deities and other supernatural forces" and therefore must be

Wildlife is a main attractive for ecotourism businesses (Giraffe at Massai Mara, Kenya)
Photo © Daniel C. Miller

worshipped (Ingles, 1997). Consequently, harvesting of such sacred species is "thought to be against the god, a belief that is still common". Forests and trees are also often linked to some cultural events. For instance, "plates made from sal leaves are essential for all ritual functions and are regarded as *chokho* (uncontaminated)." Another example of forest or tree contribution to the cultural well-being of Nepalese people is the practice that "a dead body must be carried in a green bamboo casket to the place of cremation where it has to be burned with firewood from the plant *Ficus benjamina*" (Acharya, 2003).

There are also ecological implications of these cultural practices which directly or indirectly contribute to people's well-being. It has been reported that the maintenance of religious forests, especially in hilly regions of Nepal, has had positive impacts on soil conservation and microclimate preservation. There are 40 religious forests in the Kathmandu Valley alone (NBAP, 2001). In Borneo, Meijaard *et al.* (2013) found that forest use and cultural values are highest among people who live close to the remaining forest, and especially among older Christian residents. In their study, perceived values of forests were generally high, with 48% of respondents considering the importance of forests for cultural and spiritual purposes to be very significant and 26% considering them quite significant. A study by Melnykovych and Soloviy (2014) showed that economic, environmental, social, cultural and aesthetic functions of forests contribute considerably to the well-being of forest-dependent communities in the Ukrainian Carpathians.

3.3.7 Gender considerations

Taking gender into consideration in relation to forest landscapes matters because how, why and where men and women access, use and manage forests and trees differ (Mai *et al.*, 2011; Mwangi *et al.*, 2011; Kristjanson *et al.*, 2019). Further, the feminisation of agriculture is a global trend, making gender a particularly important variable for understanding the role of trees on farms. A review of the literature on forests and gender identified persistent gender gaps across regions in access to services, access to markets and value-addition activities, land and tree tenure voice and agency, and hiring labour (Colfer *et al.*, 2016). In addition to these, gender differences in the capacity for addressing climate change have been recognised as an issue that affects not only productivity but widen existing gender gaps in many places (Pérez *et al.*, 2014). And in some areas, men's migration from rural areas has left women to assume the spectrum of agricultural and *forest management* roles, often without the resources or agency to do so successfully (Giri and Darnhofer, 2010; Jaquet *et al.*, 2015).

CIFOR's pan-tropical PEN study found evidence of distinct male and female roles in relation to the collection of forest products that vary across regions (Sunderland *et al.*, 2014). In Africa, they found that women are the main collectors of subsistence-oriented forest products, while in Latin America, they found that men dominated firewood collection. Men were also more involved in fuelwood collection in Africa than often assumed. In all regions, men were more involved in hunting, wood harvesting and mineral extraction than women. They found that in Latin America, men earn seven times more income than women from unprocessed forest products, while in Asia earnings are similar for men and women, and in Africa the share of income from forests is greater for women. With respect to income from processed forest products (e.g. furniture), the share of overall income is higher for men (61%) than women (25%) across the three regions (Sunderland et al., 2014). Women were also found to collect more forest products than men from common property resources in Latin America and Asia, but not in Africa (Jagger *et al.*, 2014; Sunderland *et al.*, 2014). This is, however, not always the case; for example, relatively few differences between men and women were found regarding the role of NTFPs in household coping strategies in South Africa (Paumgarten and Shackleton, 2011).

Harvesting from forests is often dangerous and exhausting, and collecting wood on-farm reduces the distance women have to travel and affords more time for leisure (Njenga *et al.*, 2017). Women are often responsible for managing livestock, so available shrubs also reduce the time required to gather fodder, allowing women more time for leisure activities and to prepare nutritious food for their families (Kiptot *et al.*, 2014). Women also directly earn money through the sale of milk, and the income they have control over often goes directly towards their children's education and providing nutritious food to their families (Kiptot *et al.*, 2014). Additionally, in some communities, women might benefit from the sale of fruit and fruit products (Kiptot *et al.*, 2014). Many agroforestry studies that consider nutrition outcomes highlight the importance of women and women's empowerment in decision-making as key factors determining household nutrition and dietary diversity along with agroforestry practices.

On the other hand, there is considerable variability in how the incorporation of fertiliser trees affects different population sub-groups, such as smallholder farmers, women and poorer or more marginalised households (Place *et al.*, 2005; Kuntashula and Mungatana, 2013; Coulibaly *et al.*, 2017). In many of these cases, women are often restricted in their ability to participate in agroforestry programmes due to social norms or programme design, and they often experience fewer benefits from the participation in agroforestry programmes compared to their male counterparts (Place *et al.*, 2005; Hegde and Bull, 2011). For high-value tree crop systems, such as rubber and coffee, men often control these tree crops with high commercial value, and women are often excluded from these high-value enterprises (Kiptot and Franzel, 2012).

3.4 Risk Management

Forests and trees help the poor manage risk by reducing exposure, and by providing a means to smooth income and consumption across seasons and years. In this way, they help to prevent transitory poverty and enable investments that are high risk but high return, by effectively offering insurance in the form of forest products (Shackleton and Shackleton, 2004; Paumgarten, 2005). This is especially relevant to the rural poor because they often do not have access to other forms of insurance and they often rely on activities that are subject to covariate shocks, such as variable weather, that affect entire communities (e.g. see Noack *et al.*, 2019 for the role of forests in stabilising incomes during droughts). Climate change is expected to exacerbate this situation in Africa, the region with the highest poverty rates.

Forests can help to reduce the vulnerability of households to climate change. For example, in coastal regions, mangroves buffer human settlements from tropical cyclones and storm surge (Sierra-Correa and Kintz, 2015) and on steep slopes, forests help prevent landslides in response to extreme precipitation events (de Jesús Arce-Mojica *et al.*, 2019). Unlike annual crops, many trees are able to tap into deeper water sources through their roots and produce leaves, fruits and other products during periods of water shortage or high temperatures, which also contributes to households' capacity to cope with weather and climate-related shocks (Shackleton and Shackleton, 2004; Fisher *et al.*, 2010; Place et al., 2016).

Most frameworks for risk management include both ex-ante and ex-post actions, where ex-ante may include diversification through tree-based systems (Krishna, 2011; Kristjanson *et al.*, 2019), and ex-post may include capturing income from sources that are otherwise too labour intensive or too long-term to be competitive, such as harvest of NTFPs. Investing in harvest systems for natural assets that are either slow-growing or that produce low but very consistent yields is also a form of ex-ante adaptation. Because these activities are not the first choice of households, they tend not to be recognised as an important part of local economies. However, preventing shortfalls in consumption is both a worthy end in and of itself and can contribute to long-term poverty alleviation, by helping to maintain human capital.

A large case study literature demonstrates that people use forests as safety nets, increasing their collection of NTFPs to smooth shortfalls in other income sources, especially in response to covariate shocks that limit options for the sale of assets or borrowing from neighbours. This does not appear to be the most common or the preferred strategy employed by rural people in general (Wunder *et al.*, 2014), and there is little evidence available on the relative quality or efficiency of forest-based versus other risk management strategies, such as crop insurance (for an exception, see Mbiba *et al.*, 2019). However, forests can be particularly important for remote rural populations that are poor and have few alternatives. For example, for people without access to financial services, forests and trees may act as stores of wealth in terms of both food and income sources during droughts and other events that would otherwise increase debt loads (Thorlakson and Neufeldt, 2012; Angelsen *et al.*, 2014; Wunder *et al.*, 2014).

Public demand and initiatives to conserve forest are providing new ways for poor households to diversify their incomes directly from forest landscapes, including income from wildlife conservancies and ecotourism (e.g. Andam *et al.*, 2010; Bedelian and Ogutu, 2017). Payments for environmental services, such as carbon sequestration and watershed restoration, are increasingly important income sources for local and indigenous communities in many regions (Pagiola *et al.*, 2005). Conservation policy can also affect sensitivity to climate shocks by determining access and management rights to forests that buffer income shortfalls (Lawlor *et al.*, 2019).

3.5 Forest Negative Externalities

Standing forests and trees also generate negative externalities for forest-proximate populations. That is, in addition to benefits, there are costs originating from the existence of forests, leading to harmful, unpleasant or unwanted consequences for people (Lyytimäki, 2015). The role of forest as habitat for wild animal populations leads to negative outcomes including crop-raiding, livestock predation and transfer of diseases from wildlife to livestock and humans. The effects of invasive tree species also can be considered a negative externality of forests (McGarry *et al.*, 2005; Sun *et al.*, 2006; von Dohren and Haase, 2015).

Over the last 8,000 years, about half of the forests on the planet were cleared by human activities (Foley *et al.*, 2005). This extensive loss of forests has meant an equally dramatic loss of wildlife habitat which increases the potential for human-wildlife conflict. Interaction with wildlife can also pass dangerous pathogens to livestock or human beings, such as bovine tuberculosis and rabies (Megaze *et al.*, 2017; Matseketsa *et al.*, 2019). Both the SARS-CoV, the virus that caused the SARS epidemic in China in 2003, and SARS-CoV-2, the virus that caused the 2020 COVID-19 pandemic, are believed to have originated from wildlife living in the forest (Li *et al.*, 2005; Hu *et al.,* 2017; Zhang *et al.*, 2020).

Forests generally have much higher leaf area per unit ground area than other vegetation types (Gray and Song, 2012) and some evergreen tree species have long growing seasons. In areas with limited precipitation, the water demand by trees reduces water availability for agricultural and domestic use (Sun *et al.*, 2006; Li *et al.*, 2016). Similarly, trees on farms compete with crops for water and light. However, the net effects of trees on farms depends on the balance between this increased competition and improvements in the microclimate and soil fertility (Kuyah *et al.*, 2016).

3.5.1 Crop raiding and livestock depredation

Crop raiding and livestock depredation happen wherever people live close to forests, but especially near protected areas with high wildlife density (Naughton-Treves, 1998; Karanth and Ranganathan, 2018). Crops and livestock in the buffer zones around those protected areas are convenient sources of food for some wildlife. The elephant, which is the largest crop-raiding mammal, not only destroys crops but may also cause human injuries and even death. Human-elephant conflicts happen primarily near protected areas in both Africa and South Asia. For example, Neupane *et al.* (2017) found that elephants are responsible for more than 40% of crop-raiding, causing the loss of 25% of crop production in the Terai region of Nepal. Harich *et al.* (2013) found that 84% of farmers experience crop damage from elephants around the Bia Conservation Area in Ghana.

Primates also cause serious crop damage, and it is difficult to guard against their opportunistic crop-raiding behaviour. Baboons, chimpanzees and numerous monkey species inflict damage on crops (Naughton-Treves, 1998; Tweheyo *et al.*, 2005; Mwakatobe *et al.*, 2014; Mackenzie *et al.*, 2015; Mohammed *et al.*, 2017). For example, Tweheyo *et* *al.* (2005) found that 73% of people living around the Budongo Forest Reserve in Uganda reported crop damage by primates, and 79% of the residents consider baboons to be the most destructive.

Countless other species cause crop damage. Flying fox, squirrels, birds, field rats, rabbits, porcupines, bears, wild boars and peccaries, can all cause serious crop damage. For example, wild boars are reported to cause the most damage around Tianma National Nature Reserve in Anhui, China (Zhang *et al.*, 2018) and around Kerinci Seblat National Park in Sumatra, Indonesia (Linkie *et al.*, 2007), Ramnagar Forest Division, Uttarakhand, India (Kumar *et al.*, 2017), and the Kibale National Park, Uganda (Naughton-Treves, 1998). De Carvalho *et al.* (2019) reported that nearly every household interviewed suffered from crop-raiding in a landscape with cropland intermixed with small forest patches in southeastern Brazil. The primary cause of damage was the white-eyed parakeet (*Psittacara leucophthalmus*), which attacks maize and fruit crops.

Livestock predation by wildlife is another major problem for forest-proximate people, leading to losses as high as two-thirds of household cash income (Wang and Macdonald, 2006; Holmern *et al.*, 2007). The species most commonly responsible for predation are large felids (e.g., lions, tigers, pumas, cheetahs, leopards, snow leopards and jaguars), whose predation on livestock is most widely reported (Inskip and Zimmermann, 2009). For example, in the buffer zone of the Chitwan National Park (Nepal), Dhungana *et al.* (2019) found that more than 87% of livestock lost during 2007-2016 were goats taken by leopards. Moreover, people in disadvantaged social groups suffered disproportionately more attacks in the buffer zone of the Chitwan National Park according to data records, notably because they live closer to the forest and do not have suitable protection facilities (Lamichhane *et al.*, 2018). Around the Serengeti National Park in Tanzania, Holmern *et al.* (2007) found 27.4% of livestock owners experienced loss to wild predators with an average of 4.5% or 5.3 heads of stock in a year, 97.7% of which were taken by spotted hyenas, followed by leopard (1.6%), baboons (0.5%) and lions (0.1%). Wang and Macdonald (2006) reported that leopards, tigers, Himalayan black bear and dhole are the primary animals that attack livestock in the Jigme Singye Wangchuck National Park, central Bhutan, causing an average 17% loss in cash income by affected households. At higher elevations, snow leopards are the primary predator of livestock (e.g. Chetri *et al.*, 2019 for the Central Himalayas of Nepal). Demonstrating that this is a long-standing problem Mishra, (1997) reported that in the Indian trans-Himalaya (Kibber Wildlife Sanctuary), snow leopard and wolf are the primary livestock predators, causing a loss of 18% of livestock holdings over a period of 18 months. Although some governments or conservation management agencies provide financial compensation to livestock owners for the loss of livestock to wildlife depredation, the compensation is often far below the actual cost, e.g. only accounting for 3% of the perceived annual loss in the Kibber Wildlife Sanctuary (Mishra, 1997).

While the most prominent and well-publicised cases of human-wildlife conflict are often those around protected areas, conflicts can happen anywhere in forested landscapes. Michalski *et al.* (2006) reported that jaguars and pumas were the main animals attacking cattle in a fragmented forest landscape in the southern Brazilian Amazonia, with damages of up to USD 885 per year per farm. Bista and Song (under review) found local residents suffered significant economic loss from wildlife in the Middle Hills of Nepal where forest conditions had improved significantly from community forestry. On the other hand, around the Nilgiris Biosphere Research and Bhadra Tiger Reserve in the Western Ghats of India, Puyravaud *et al.* (2019) found that deforestation increased the frequency of crop-raiding by elephants.

3.5.2 Negative effects of trees

Forests, and especially high productivity *forest plantations*, are major water users and thus compete with other downstream uses of water (Calder, 2007). This may be especially true of the fast-growing and non-native species planted in industrial plantations, such as ponderosa pine (*Pinus ponderosa*) plantations in the forest-steppe ecotone in western Patagonia (Licata *et al.*, 2008). Sun *et al.* (2006) estimated that extensive forest plantations in China could reduce the water yield by 50 mm/year or 50% in the semi-arid region of the Loess Plateau, and as much as 300 mm/year or 30% in the tropical south. Yu *et al.* (2010) estimated that a 10% increase in forest cover would lead to 25.6 mm/year or 13% of water yield reduction in a watershed in the Qilian Mountains of northwest China. Zhang *et al.* (2018) identified a lack of water as a major factor contributing to cropland abandonment in a rural community in China.

This competition for water must be seen in the context of the overall relationship between water availability and forests and trees, as reviewed by the 2018 Global Forest Expert Panel of the Collaborative Partnership on Forests (Creed and van

Noordwijk, 2018). On the one hand, forests – especially natural forests – contribute to the resilience of water supply through conservation of soil and water resources, providing freshwater during dry seasons and mitigating floods during wet seasons in many parts of the world. On the other hand, forests – especially fast-growing plantations – use water themselves, reducing freshwater availability (Kim *et al.*, 2014). A systems approach that integrates hydrological processes at all scales is needed to understand the role of forests in water availability and the subsequent impact on people's livelihood under a changing climate. If properly managed, forests can help enhance the resilience and quality of water supplies.

Some tree species that are planted can also become invasive, and in turn, compete for water and growing space. This is particularly true of species that have deep roots, high transpiration rate and a long growing season. In South Africa, the invasive species black wattle, *Eucalyptus* and pines can blanket the landscape with non-native forests (McGarry *et al.*, 2005). Le Maitre *et al.* (2019) estimated that forests of these invasive alien species use as much as 970 m^3/ha/year of water, having a significant negative effect on the Western Cape water supply system. Guava (*Psidium guajava*) and its sister species strawberry guava (*Psidium cattlenianum*), native species to tropical America, have become invasive in many parts of the world, including Australia, southern Africa, southeast US, Hawaii, Galapagos Islands and Madagascar, following human introduction. Many are dispersed by seeds and regenerate by root suckering and are extremely difficult to remove and almost impossible to eradicate (Walsh *et al.*, 2008; DeSisto *et al.*, 2020). These tree species drastically change the character of the ecosystems that they invade, including cropland and pastures.

This is related to the phenomena of woody encroachment and expansion (also known as "bush encroachment" or "woody thickening"). This process, whereby trees become more numerous, larger or expand into open ecosystems such as grasslands, has been widely reported in the dry tropics of Africa and to a lesser extent in Australia and Latin America (Liu *et al.*, 2015; Skowno *et al.*, 2017; Stevens *et al.*, 2017). The causes of encroachment and its heterogeneous manifestation remain controversial, but CO_2 fertilisation, climate change and land use management have all been suggested as possibilities (Bond and Midgley, 2012; Abreu *et al.*, 2017; Venter *et al.*, 2018), and some models predict it will increase rapidly over the coming century (Higgins and Scheiter, 2012).

Woody encroachment is often associated with negative impacts on biodiversity (Parr *et al.*, 2012; Ratajczak *et al.*, 2012; Parr et al., 2014) as many species require the open habitat that is lost. There are also large potential impacts on social well-being and rural economic activities. These include the loss or reduction in productivity of grazing land and the extra costs incurred by pastoralists or ranchers for 'debushing' or thicket clearance (Stafford *et al.*, 2017). These impacts can have severe consequences for livelihoods during drought years (Angassa and Oba, 2008). There is also concern that if open savannahs become more woody, then they will be less attractive to tourists interested in viewing large mammals (Gray and Bond, 2013).

3.5.3. Winners and losers

Most people lose in human-wildlife conflicts, but some more than others. Poor people bear the brunt of the impacts and stand to lose the most with respect to their total income. Losses of crops and livestock and human injuries or casualties are the direct costs of human-wildlife conflicts. There are also numerous indirect costs as reviewed by Barua *et al.* (2013). Crop damage contributes to food insecurity among the rural poor. The potential of wildlife-caused human injury or mortality stokes fears in residents, damaging psychosocial well-being. For example, Jadhav and Barua (2012) argue that the fear of an elephant attack exacerbates the mental illness of marginalised people, imposing greater health damage than the physical threat. To mitigate wildlife impacts, farmers engage in extensive guarding, sometimes day and night, and divert limited financial resources to purchase materials for fences and stalls. School-age boys may be deployed to guard crops during peak crop-raiding time, compromising their performance at school (Mackenzie *et al.*, 2015).

There are also some hidden ecosystem service benefits of crop-raiding. In South African macadamia orchards, bats and birds directly reduce yields by 26%, but at the same time, they serve as a biocontrol for insects. Exclusion of bats and birds resulted in losses of up to 60% of yield to insects (Linden *et al.*, 2019). Therefore, the presence of bats and birds provides a net gain in macadamia orchards. Byg *et al.* (2017) argued for a 'disaggregated accounting' of both forest services and disservices, and their distribution across people and places. For example, some of the species involved in human-wildlife conflicts are highly attractive to tourists and may, therefore, generate higher revenues from ecotourism than losses from crop-raiding and livestock predation.

Likewise, the impacts of invasive alien tree species on local people's livelihoods are complicated,

Smallholder logging activities in the state of Amapá, Brazil
Photo © Reem Hajjar

as reviewed by McGarry *et al.* (2005). Depending on the traits of an invasive species and its invasion history, its impacts on people's livelihoods can be extremely disruptive, neutral, or positive. For the same invasive alien species, it may have a large range of influences for different people depending on their culture and adaptability. For example, some invasive alien tree species may take up precious space, disrupting subsistence agriculture. But other people can take advantage of the species by harvesting valuable components, such as fruit, nuts or wood to burn as firewood or convert to charcoal for sale. This further depends on people's ability to manage these species to neutralise their negative impacts (McGarry *et al.*, 2005).

3.6 Negative Impacts of Deforestation and Forest Ecosystem Disturbance

The negative impacts of deforestation lie on the other side of the coin from the ecosystem services provided by standing forests. Such negative impacts include both the direct effects of land-use changes and the effects of other simultaneous changes. The direct effects of deforestation include the physical effects of road construction, reduction in tree cover, and habitat *fragmentation* (Laurance, 1999; Evans, 2016). These may, for example, change the hydroclimate, with potentially more variable rainfall (De Sales *et al.,* 2020). As this report is written in the context of the COVID-19 pandemic that is believed to have originated in wildlife markets (Mackenzie and Smith, 2020), we focus here on the public health implications of deforestation.

A causal chain links land use change and the spread of zoonotic diseases. For example, changes in land-use associated with mining, agriculture and plantations bring about new risk factors that affect the transmission of diseases (Bauch *et al.*, 2015; Whitmee *et al.*, 2015). As habitats are altered, so is the predator-prey relationship leading to a change in the ecological regulation of parasitic diseases. This change also leads to a reduction in the diversity of organisms, and facilitates the flow of pathogens. In-migration and human population growth accompany deforestation, resulting in greater exposure to disease. In turn, diseases that may not have been viable in small populations may thrive and become endemic. In addition, and in similar ways, deforestation may also increase the likelihood of emergent infectious diseases by increasing contact between forest animals, domestic animals and humans (Patz *et al.*, 2005). For example, encroachment into forest lands is thought to have been a factor in the emergence of several viral diseases including Ebola, Marburg, Nipiah and Ross River Viruses (Chua *et al.*, 2002). Similarly, the loss of forests and the construction of roads leading to an increase in bushmeat hunting and trade are thought to have contributed to the original zoonosis of HIV (Wolfe *et al.,* 2004).

Conversion of forests and the alteration of physical characteristics may create new breeding sites for populations of disease-carrying organisms, alter micro-climatic conditions and eventually lead to the emergence of zoonotic diseases (Dobson *et al.*, 2020; Gibb *et al.*, 2020). Road building, mining pits and logging can all create new breeding grounds for insect vectors such as mosquitoes. For example, in the Peruvian Amazon, the biting rate of the malaria carrying mosquito *Anopheles darlingi* was found to be proportional to the area of land modification and inversely proportional to the area of remaining forest (Vittor *et al.*, 2006). In some instances changes in habitat have had positive effects on the prevalence of infectious diseases. For example, in many parts of sub-Saharan Africa, a reduction in the prevalence of malaria has been traced back to the draining of wetlands (Keiser *et al.*, 2005). Equally, in Thailand, deforestation is thought to have reduced the overall burden of malaria (Yasuoka and Levins, 2007). Overall, negative effects of deforestation in terms of disease prevalence, however, outweigh positive effects (Melrose, 2011). In their study in the Amazon, MacDonald and Mordecai (2019) found that deforestation increases the risk of malaria transmission. Garg (2019) found similar results in Indonesia, concluding that primary forest loss increased the incidence of malaria based on robust counterfactual estimation methods. In contrast, in their study across sub-Saharan Africa, Bauhoff and Busch (2020) found no relationship between deforestation and malaria, suggesting that the socioeconomics of deforestation may be different in that region compared to Latin American and Asian contexts.

3.7 Conclusions

Evidence from around the world shows that the goods and ecosystem services of forests and tree-based systems can play important roles in poverty alleviation, especially by consistently contributing to income or consumption, thereby helping poor households secure their socio-economic and cultural status. In particular contexts, poor households also use forests and trees on farms to exit poverty and to mitigate risks, thereby avoiding transient poverty. On the other hand, those forests and trees may also generate negative externalities that contribute to trapping or moving households into poverty. All four forest-poverty relationships are strongly context-dependent: which relationship manifests in a particular location depends on the natural resource endowment and cultural, religious, economic, political and institutional setting. However, regardless of context, there are relatively few documented cases of forests or trees either being the primary *pathway out of poverty* or generating significant negative externalities, and thus it is not possible to draw any general conclusions about those dynamics.

The contrast between the widespread dependence of the poor on forests and trees for their livelihoods and well-being, but their limited ability to use those same resources to exit poverty, begs an explanation. Possibilities that deserve more consideration include the influence of international investment and trade on the allocation of benefits from forests and the influence of the rules governing access to forests on the global distribution of prosperity. More research on the dynamics between forests and *inequality* across countries is merited.

While forests and trees also do not offer a 'silver bullet' for securing or stabilising well-being, there is more evidence that the poor have been able to harness them to meet these objectives. The role of forests and trees is relatively more important in locations that are remote and thus offer limited access to markets and public services. Further, this role may become more important with climate change, as a way to maintain livelihoods and manage risks in a future that presents ever more challenges for the rural poor.

3.8 References

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